

NASA-CR-201932

TRANSFER RESEARCH AND
IMPACT STUDIES PROGRAM

Case Development
Task Report

June 1985



DENVER RESEARCH INSTITUTE
UNIVERSITY OF DENVER

TRANSFER RESEARCH AND IMPACT STUDIES PROGRAM

Case Development Task Report

- Prepared for -

Office of Commercial Programs
Technology Utilization Division
National Aeronautics and Space Administration
Washington, DC 20546

Contract NASW-3466

- Prepared by -

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June 1985

Case Development Task Report--End of Contract NASW-3466 4th Year

The Denver Research Institute (DRI) at the University of Denver has been assigned the task of case development under contract to NASA Headquarters since the first contract, establishing the Program for the Analysis of Technology Transfer (PATT), was awarded in November 1967. The program name was changed to Transfer Research and Impact Studies (TRIS) in February 1972.

Case development was defined as the documentation of incidents of the transfer of technology developed by or for the space program from its primary use in the space program to its secondary terrestrial application(s), such documentation to be conducted on a continual basis, tracking the process of technology transfer over the years. DRI began such data collection in 1968 and has continued to add new cases and to follow the progress of those already documented.

Over this 17 year span, the nature of the case development task has varied along with the use of the cases. The case development effort has contributed to special studies of different aspects of the technology transfer process, such as cost-benefit evaluation, and also has contributed to NASA's positive public image, assisting PR publications such as Spinoff, and being cited in congressional testimony. At least one issue of Space Benefits was printed in its entirety in the Congressional Record.

By 1980 DRI's transfer example files covered 812 discrete technologies and about 1,800 separate cases of those technologies' transfers. Selection and discovery of these cases was based on a degree of evidence that a transfer had occurred. Because these cases were collected on the basis of indicated successful transfer, it is not claimed that they comprise a representative sample of technology transfer incidents emanating from the space program nor from NASA's Technology Transfer Program. Taken together or singly, however,

they do reveal, in hindsight, something about the effectiveness and value of technology transfer.

Collecting Case Development Data

Since collection of case development data began in 1968, the program staff has refined the methodology involved. The vast bulk of data collection has been done via telephone interviews; occasionally face-to-face interviews have been possible. Either way, such interviews have always been open-ended due to the highly variable nature of the technology transfer process. However, common elements of the process have been identified as critical to an understanding of the process. As DRI became more knowledgeable about these elements, case documentation changed from simply relating the events in a chronological fashion to developing categories where the information collected could be more systematically organized for purposes of cataloguing, or for analyzing and reporting consolidated data.

The following outline of the data items from cases recently documented guided DRI's case development efforts:

1. The NASA technology involved, including:
 - a. description in lay terms;
 - b. why it was needed for the space program and how NASA used it;
 - c. who worked on it, when, and under what conditions (for example, in a NASA Field Center laboratory or under contract);
 - d. NASA documents produced about the technology;
 - e. patent, license, or waiver status; and
 - f. how NASA disseminated the technology, that is, let others know of its existence.
2. The transfer and application, that is, the description of the secondary application that conveys how the transfer process occurred, including:
 - a. the user institution or organization and its location;
 - b. an explanation of the user's need, use, and implementation of the technology;
 - c. the transfer mechanism(s), that is, how the user heard about the existence of and obtained the NASA technology;
 - d. barriers and incentives affecting the use;
 - e. who will be affected by the secondary application, that is, the user's clientele; and
 - f. the future status of the use.

3. The costs incurred, benefits accrued or losses realized by the user due to the transfer, measured as quantitatively as possible, including:
 - a. product, process, or service improved or not;
 - b. net time or materials saved or not;
 - c. sales or income increased or not;
 - d. productivity increased or not;
 - e. working conditions improved or not; and
 - f. living conditions or quality of life improved or not.

See Appendix I for a more complete list of instructions to the interviewers, called Case Report Form Guidelines.

In 1974 DRI produced the first issue of a publication titled Space Benefits: The Secondary Application of Aerospace Technology in Other Sectors of the Economy. Space Benefits was updated and published on an annual basis through 1980 when the last issue, 81-1, was made available. It was a compendium of the "best" cases from DRI's files, presented in summary form. Cases were indexed by key term(s), by user institution or organization, by user's state of location, and by NASA Field Center(s) involved in the technology's development. Cases were organized into twenty economic sectors pertinent to the secondary application: Manufacturing Consumer Products, Manufacturing Capital Goods, and so on. See Appendix II Table of Contents Section II for the full list of economic sectors and for the introduction to the last issue of Space Benefits, called Transfer Overview, and some sample pages.

With the publication of 81-1, it was decided that such information could be presented in a more meaningful and useful way to its readership, which was assumed to comprise the public, government officials at all levels, academicians, the media, and other lay audiences. Subsequently the Case Report Form Guidelines appearing in Appendix I were introduced. A revised version of Space Benefits was planned, containing the Case Synopsis, Estimated Value, and NASA References sections of the Guidelines in place of the choppy "paragraphs." Data for the four indexing schemes would be coded and entered into the computer for each case, DRI at this time having acquired a microcomputer.

The source of cases for this revised version would be: (1) DRI's old cases already on file, especially those appearing in 81-1; and, (2) newly developed cases based on indications of outstanding technology transfer performance.

Results of the Case Update Effort

By the time the update effort began DRI had already collected files on 812 technologies, exemplified by an estimated 1,800 cases of secondary application. The first step was to review each of the 1,800 cases in the 812 files and evaluate their contents. Value was based on "meatiness" of the story, that is, how much it contributed to knowledge of the technology transfer process and how much it revealed about technology transfer's various components. Although this could include cases in which the transfer failed for some reason as well as those of successful transfer, the latter made up the vast majority of cases because that was the type of case traditionally followed and fully documented by previous procedures.

This case and file review, combined with knowledge of DRI's case development history, revealed some interesting facts about the collection of cases and how they were somewhat out of balance—not only from a benefits standpoint but in other ways as well.

The first revelation concerns the 812 technologies. Under the old system, a "technology" came to be defined as a single piece of scientific R&D, often limited to a single NASA document. Thus, a technological area such as nondestructive testing, to which space program R&D greatly contributed, appears in at least twenty DRI "technology" files, including:

- Nondestructive Testing Handbooks
- Nondestructive Test Identifies Metals
- Nondestructive Test Monitors In-Process Weld Quality
- Ultrasonic System (NDT) Automatically Detects and Records Fatigue Crack Growth
- Nondestructive Testing Manuals
- Nondestructive Testing of Brazed Joints
- Instruction Manuals for Liquid Penetrant Nondestructive Testing
- Handbooks for Nondestructive Testing Using Ultrasonics

- Instruction Manuals for Radiographic Nondestructive Testing
- Nondestructive Spot Tests Allow Rapid Identification of Metals
- Nondestructive Method for Measuring Residual Stresses in Metals, A Concept
- 1966 NDT Symposium on Nondestructive Testing Trends and Techniques
- Nondestructive Testing of Honeycomb Structures
- Nondestructive Testing of Welds on Thin-Walled Tubing
- Qualification and Certification of Nondestructive Testing Personnel
- Guidebook of Nondestructive Evaluation Techniques for Materials and Structures

Even heat pipe technology is spread across three "technology" files:

- Heat Pipe Applications
- A Rotating, Noncapillary Heat Pipe
- The Heat Pipe--A Simple, Versatile, Efficient Heat Transfer Tool

The revised case development effort sought to consolidate what could be considered sub-areas of a wide-ranging technological category. File titles were assigned to reflect the broader scope of what constituted a "technology." The computer coding and indexing scheme more specifically categorized the technical subject areas involved. See Appendix III for a list of these subject areas.

Second, and again due to the restricted definition of a file, case and file review led to the rediscovery that one transfer example could be included in more than one file. Even though the transfer story might be word-for-word identical, if a case was deemed to cover more than one technology, it was included in each technology's file. In some cases this was appropriate and the practice would have been continued. More often, however, these involved files and technologies in need of consolidation. For example, three files--Manson-Haferd Time-Temperature Parameter/Manson-Ensign Time-Temperature Analysis, High Temperature Fatigue Analysis, and Fracture Mechanics--were combined into one file in the updated system titled Materials Behavior Prediction Methods.

Third, it became apparent that the definition of "the user" was not consistent throughout the collection of cases. If NASA is considered the

primary user of the technology, then the entity that applies the technology to a nonaerospace area is considered the secondary user. Cases were to be developed on secondary users. However, occasionally a "case" would be documented about customers or beneficiaries of the secondary users' products—what might be termed tertiary users. For example, results of NASA R&D on nonflammable materials technology were used by a company to produce a fireproof fiber and a case was written about this transfer. The company sold its fiber to another company which used it to make protective clothing for firefighters, and a separate case documents this tertiary use story. Care was taken in the update effort to put the stories of tertiary users in their proper place—within the secondary users' stories.

Final tallies of the actual number of discrete technological areas (files) and examples of secondary use (cases) in the old system were not made. It was not considered worth the effort. Whenever numbers about the old files and cases are given, therefore, the above three factors must be taken into account.

Another number that has been quoted in statements of case development task results also merits further explanation. This is the number of active "paragraphs" in Space Benefits 81-1. Under the former case development procedures, a paragraph represented a technology as it was then defined in its most restrictive sense. And, just as a case could be spread across more than one technology file, so could a case be used in more than one paragraph. If a case was pertinent to several of the economic sectors, it was repeated in each of those sections of the publication. The same user of a technology dealing with heat shield coating for reentry vehicles applied it to protect high-rise building components and railroad cars carrying hazardous materials, and thus appears in the section on Construction and the section on Rail Transportation. The actual number of distinct cases in 81-1 was not determined. According to

the preface of 81-1, the 443 active paragraphs describe 585 case examples.

Given the above restrictions and cautions, the following results of the phase-out of case development activity on contract NASW-3466 are presented.

Files

From 1968 to 1980 DRI created 812 files—where "file" is defined in its most restrictive sense, as explained. All 812 were reviewed and 138 were updated. Of the 138, 130 were transferred into the new system and incorporated into 111 new files; 8 were declared inactive, i.e., could not be reached and/or transfer of NASA technology could not be confirmed.

The new system contains 132 files representing the 111 created from updates and 21 documented from scratch.

Cases

In the old system there were 1,790 documented instances of technology transfer attempts, called cases; 1,688 were documented by DRI and 102 came from other sources engaged in benefits reporting, such as the IACs, COSMIC, and the various applications teams. All of these were reviewed. Many (an exact count was not kept) had been declared terminated over the years as the use of the NASA technology was terminated; many others were deemed poor candidates for follow-up since the most recent recontact had been a decade or longer ago.

Following this case by case review, 186 were updated; 8 were declared inactive and 178 were incorporated into 149 cases under the new system. The smaller number of new system cases is due to several factors, among them the merging of like technologies and the inclusion of third party beneficiary cases into the story about the second (i.e., post-NASA) user.

In addition to the 149 cases transferred from the old system, 38 brand new cases were documented for a total of 187 cases.

Space Benefits

Space Benefits 81-1 contains 443 paragraphs, an unknown number of which represent repetition of the same story in more than one of the 20 sections. The paragraphs were derived from 298 of the old system files and represent 538 cases (with duplication). Previous issues of Space Benefits had included 114 more paragraphs derived from 63 additional files; these paragraphs were deleted as cases terminated over the years.

Of the 298 files in 81-1, 128 were updated; 8 were declared inactive and 120 were incorporated into 101 of the new system files. Of the 538 cases in 81-1, 209 were updated (again, duplication is not taken into account); 8 were declared inactive and 201 were consolidated into 146 of the new system cases.

In all, 160 of the paragraphs in 81-1 were updated.

Lessons Learned

As the case development task concludes, DRI can call upon its years of experience to draw some conclusions about NASA case development.

First, it is important to begin the case early in its development—sometimes even in the technology's formative stages—and to track cases over time—sometimes an extended period of time. The technology transfer process can take a long time to complete. In addition, it has been hypothesized that the earlier in the technology's development the secondary user becomes involved, the broader the span of potential secondary applications.

A more thorough and effective case development procedure would concentrate on a few longterm stories rather than many one-shot contacts. During the review of all of the already existing cases in DRI's files, a great many had to be put aside because the last contact had been made a decade or more ago. Some that were contacted after many years could not be found anymore, or the transfer could not be confirmed by personnel available. These cases had to be declared inactive and set aside.

When the first Space Benefits was produced in 1974, it focused attention upon successful, completed transfers. Cases in an early stage of development were dropped and were bypassed in the subsequent case development effort which was targeted to update cases already in Space Benefits or documentation of new cases. Cases that may have been on their way to becoming valuable transfer stories thus were lost.

The focus on completed, successful transfer stories leads to another conclusion: it can be as important to document failed attempts at transfer as successful attempts. We know that most failures are not due to the technology involved but due to other barriers, like market conditions, the national economy, patent law, or a key person. If NASA is serious about promoting technology transfer, there has to be an understanding of why things don't work as well as why they do. The task as defined for DRI, however, attached no importance to "problem" or less than successful cases.

Third, DRI learned that it was possible to create a system of computer coding for case development access. The coding scheme developed by DRI, called CASECODE (see Appendix IV for a list of coded items), while in need of revision based on experience with its effectiveness, showed that various key pieces of data could be extracted and entered on computer for easy access. Included in these data is the information needed to produce the Space Benefits indexes: subject area, user organization, user state of location, and NASA facilities involved in the transfer.

Fourth, DRI learned that one area important to case documentation was extremely difficult to collect: the quantification of costs and benefits or losses. The case contacts had little trouble categorizing or describing performance in these areas, but more often than not could not or would not supply quantified estimates. It is suggested that such an effort be considered a separate effort, in which every attempt would be made to contact the

proper people who can supply such information. The cases in DRI's files are full of numbers that should be treated skeptically as they do not represent such an effort. Furthermore, attempts to assess the worth of the space program or the NASA technology transfer effort by adding up these figures or those in Space Benefits should be avoided because of the inconsistent manner in which they were collected and quoted, as well as the fact that the cases do not claim to be representative of either program. In fact, the following disclaimer appears in the preface to Space Benefits 81-1: "The examples in this publication are only a portion of all such transfer activity and, therefore, do not indicate the magnitude of technological effects from NASA programs."

Fifth, the case development task showed that technology transfer is larger than the activities of the Technology Utilization Office alone. Technology transfer can occur without a conscious or programmed effort made on anyone's part. Therefore, it is important to document the entire range of transfer activities, from an engineer using knowledge gained from a NASA contract in a nonaerospace effort to a reader ordering a Technical Support Package from NASA Tech Briefs. It has been hypothesized, in fact, that the efficiency of the transfer decreases as the mechanism connecting the user with the technology becomes less personal and more oriented to large-scale distribution systems. Effective case development should address this concern. This direction would require a network of mutual awareness and support between each NASA facility and the case development team.

Finally, the case development effort carried out by DRI showed that people, from bench scientist to corporate officer, are quite willing to provide extensive, useful information to a representative of an academic institution calling on behalf of NASA.

APPENDIX I

Note: All information through the COSTS AND BENEFITS category describes the case and can be publicly released--for example, in a casebook or as feedback to the contact or TU Program. Therefore, it contains no proprietary information and no person names. Information starting with PROPRIETARY INFORMATION category is for internal use or release for Spinoff follow-up only and should not even be sent to the case contact.

File No.: Assigned chronologically starting with "1000."

Case No.: Assigned chronologically within file starting with "01."

Dates: Contact Date is latest date on which information was collected; Previous Contact Date is "N/A" for the first write-up.

TITLE: A brief phrase identifying the technology.

SUBTITLE: A brief phrase identifying the application (i.e., a case title).

CASE SYNOPSIS: This paragraph summarizes the detailed information presented in the sections NASA TECHNOLOGY and TRANSFER AND APPLICATION. It contains:

1. identity of user entity and state location
2. description of technology and NASA center
3. description of use
4. description of the transfer (mechanism, problems, status)
5. future expectations

ESTIMATED VALUE: Synopsis of COSTS AND BENEFITS.

NASA REFERENCES: Reference numbers of specific NASA documentation (TBJ, S/O, CR, TM, SP, PR, etc.) concerning this case, i.e., NASA documents either used by the case contact or which will provide more information re this technology.

NASA TECHNOLOGY: Information includes:

1. technology described in layman's terms
2. why it was needed and how NASA used it
3. who did it, when, under what conditions (i.e., contract, subcontract)
4. patent/license/waiver status
5. dissemination methods used by NASA
6. NASA documents involved (number and title)

TRANSFER AND APPLICATION: The description of the secondary application of NASA technology tells the full story of the transfer process. Information includes:

1. user entity name and state location (never use person names)
2. explanation of need, use, implementation
3. transfer mechanism(s) (how user heard about and obtained the NASA technology)
4. barriers and incentives
5. tertiary beneficiaries (e.g., customers, students, patients, etc.)
6. future status

COSTS AND BENEFITS: Describe benefits, losses, costs; attempt to obtain quantitative measures. Examples of benefits are:

1. product/process/service improved
2. net time/materials savings
3. sales/income increased
4. productivity increased
5. working conditions improved
6. living conditions (quality of life) improved

Case Report Form Guidelines (continued)

(new page)

PROPRIETARY INFORMATION: Include here all information the contact indicates as proprietary.

COMMENTS: Include here an assessment of the case's potential value from our perspective and suggestions for follow-up, including other contacts, date of follow-up, and interviewing problems to watch for. This section would also include: contact's reference to other NASA technology, other non-NASA sources of the technology, the TUP; past use of the case (e.g., Spinoff year and page reference); previous Transfer Example File and Case numbers.

CONTACTS: Completely identify the source(s) of reported information, including NASA employees:

1. name
2. title or position
3. department/division/subsidiary/company/etc. (include all that apply)
4. address
5. phone number

If there is more than one contact, give this information for each, along with an explanation of the kind of information each contact provided. Ancillary information that may be collected about contacts includes years at company, years in present position, education.

ORGANIZATIONAL CHARACTERISTICS: Includes size (number of employees), products, and annual sales of the contact's place of work. Sometimes this will be available for the division or subsidiary, and sometimes only for the parent company. Such information is not relevant for institutions like universities and hospitals.

AVAILABILITY OF VISUALS/LITERATURE: Always ask for product literature, reports, articles, etc. Visuals in the form of color transparencies or photos will be needed for Spinoff cases.

SOURCE OF LEAD: Explain how we learned of this case.

INTERVIEWER: Your name.

APPENDIX II

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- D. Electric Utilities
- E. Environmental Quality
- F. Food Production and Processing
- G. Government
- H. Energy
- I. Construction
- J. Law Enforcement
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- L. Rail Transportation
- M. Air Transportation
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SECTION III. INDEXES

General Index
Organization Index
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*All benefits paragraphs updated or new in this edition are designated with a plus sign (+) in the left-hand margin. The position of the plus sign indicates the starting point for new information (e.g., if next to the first line, the paragraph is new or was deleted in this edition).

TRANSFER OVERVIEW

New technology generated by NASA programs represents a major addition to the nation's total reservoir of technology. This section presents a brief overview of the scope, transfer processes, and benefits surrounding technical innovations included in Space Benefits.

Scope of Technical Innovations Reported

NASA in-house and contractor R&D activities span more than 30 major technical disciplines in standard engineering fields. These activities have created a wide range of specific innovations including equipment designs, processes, technical expertise and design data. The scope of NASA contributions reported in Space Benefits is indicated below.

Indirect applications. A vast majority of the benefit examples report adaptation and use of technology originally developed to satisfy NASA mission requirements. These indirect, or "secondary," applications found their way to the marketplace as new or improved products, processes or services.

Direct applications. A relatively small number of the benefit examples describe the direct application of NASA technology by the private sector or by public sector organizations. For example, NASA research in aeronautics has directly influenced aircraft design, and satellite technology has directly affected weather forecasting, navigation, etc. In some instances, NASA, in conjunction with private industry and/or other federal agencies, has developed secondary applications to satisfy well-defined public needs.

Off-the-shelf products. NASA purchases off-the-shelf products for use in its primary mission-oriented programs. If this type of procurement activity did not require product improvement or otherwise contribute to innovations in the product line, the product is not included in this document.

Management techniques. Benefit examples involving specific innovations in management practice are included because management is considered a technical field.

Transfer Modes

The availability of NASA technology alone is not sufficient to generate beneficial change in the nation's economic system: it is also necessary that potential users acquire, select, adapt and implement such innovations within the economic system. These activities constitute the technology transfer process. Transfer research has shown that several factors are important in determining the economic effects of this process. The major factors are: type of technological innovation; method of acquisition (i.e., transfer mode); and technological environment of the recipient.

Transfer modes are significant in the process because they can be configured, selected, and managed to a greater extent than any other factor. A single innovation, for example, might generate similar benefits per application for several secondary users, but the transfer cost could vary by orders of magnitude depending on which transfer mode is used.

Eight common transfer modes have been identified among the hundreds of examples reported herein:

Mode I: Diversification by firms producing for NASA programs through (a) shifts in production facilities and personnel to commercial product lines, or (b) implementation of formal organizational policies to apply mission-related expertise in commercial product development projects.

Mode II: General improvement of industrial production practice and product quality through NASA-initiated specifications and standards for mission hardware procurement.

Mode III: Development by industrial firms of new process or product technology, with NASA as the first market, and subsequent commercial production because additional markets and applications are recognized.

Mode IV: Relocation of skilled individuals from NASA-funded employment to employment in other economic sectors, resulting in the application of acquired skills to solve engineering or management problems encountered in the new sectors.

Mode V: Professional activities, including professional design code development, by researchers involved with NASA's basic and applied R&D programs.

Mode VI: Formal NASA programs that disseminate or adapt mission-generated technology for organizations in other economic sectors.

Mode VII: Direct access to NASA personnel or the Agency's scientific and technical information systems by other organizations as part of their normal information acquisition efforts.

Mode VIII: Interagency projects in which NASA adapts or develops technology for the needs of a second agency or the organizations that are aligned with the second agency.

NASA efforts to stimulate technology utilization have involved the deliberate use of Modes V through VIII, as well as Mode III. Most of these have been conducted by the Technology Transfer Division, which operates a range of transfer services in Mode VI. There is little systematic management of transfer activity outside Mode VI except for the private efforts of a few contractors in Modes I through IV. Transfer costs, success rate, and total number of successful transfers for an innovation vary widely, even within Mode VI.

Economic Benefits

Economic benefits from technology transfer activities have been defined in various ways. The definition used here is based on the beneficiary's judgment concerning technical alternatives. That is, benefits are measured as the difference in economic effects from applying a NASA innovation as compared to the technical alternative that would have been used.

Economic data are not available for some transfer examples because the data may not be estimable or they may be proprietary. In some Space Benefits examples, sales data are given to indicate the level of economic activity associated with the transfer example; however, such data do not represent benefits attributable to NASA technology since other technologies, capital expenditures and/or labor costs were also required to produce the goods or services involved.

In general, technological innovation is an investment activity and NASA technical contributions add to the availability of such investment opportunities. In this context, benefits occur when NASA technology provides a better return than alternative opportunities. One of the important objectives for government-operated transfer services is to increase the efficiency of technological evolution within the economic system by reducing the total costs of individual searching in the market place for technology investment opportunities. Technology transfer is the subject of considerable research activity in the U.S. and internationally since it has the potential for reducing costs in technological evolution. In order to achieve this potential, however, the process must be systematically analyzed, developed and managed. Current research is directed toward this goal.

A. MANUFACTURING CONSUMER PRODUCTS (CONT.)

- 7 Optical alignment training manual: compiled by Marshall. . . . incorporated into standard operating procedures at Eastman Kodak Co. (New York) for aligning optical testing instruments. . . . accuracy improved. (TB/TSP, TEF 208, Case No. 32414, 10/78)
- 8 Intumescent fire retardant coatings: developed by Ames. . . . used, under NASA license, by AVCO Corp., Specialty Materials Div. (Massachusetts) to develop commercial product line. . . . FLAMAREST intumescent paint and FIRE-FLEX intumescent tape and sheet sold to manufacturers of inboard pleasure boats. . . . used on hulls, fuel hoses and tanks, and other fuel storage containers. . . . improves fire safety for boating. (License, TEF 554, Case No. 108481, 9/79)
- 9 Dry lubricant coating processes for metals: research need identified in quality control study conducted for Headquarters by General Magnaplate Corp. (New Jersey). . . . company developed and patented 4 processes to bond dry lubricants, such as Du Pont's Teflon, on metal surfaces for space applications. . . . many components for Apollo, Viking, Skylab, and Shuttle coated by General Magnaplate. . . . commercial coating services introduced; annual sales are \$2 million. . . . over 700 manufacturing clients include GE, IBM, RCA, Westinghouse, Polaroid, and ITT. . . . applications include production equipment for hundreds of household items such as molded plastic products, dog biscuits and birth control pills, as well as products such as computer components, office equipment, packaging machinery, turbines, valves and racing car components. . . . coated production equipment enables longer wear life, higher operating speeds, and cleaner operation. . . . increases productivity and lowers unit cost. . . . two Japanese companies, including Mitsubishi Corp., one Israeli company, and one Swedish company licensed to use processes. (Contractor, TEF 575, Case No. 109338, 8/79)
- 10 Microbiological handbook: compiled for Marshall. . . . used regularly by Astra Pharmaceutical Products, Inc. (Massachusetts) to familiarize employees with biological fundamentals of plant cleanliness. . . . company manufactures prescription and over-the-counter drugs. . . . company saved \$35,000-\$40,000 by not having to compile same information. (Professional society/TSP, TEF 402, Case No. 112994, 11/79)
- 11 Black chrome coating properties for solar energy collectors: compiled by Lewis. . . . used by Chamberlain Manufacturing Corp. (Iowa) in selecting black chrome for its solar collector product line. . . . flat collector panels coated for Chamberlain by Olympic/National Plating Co. (Ohio) using process developed by Olympic in conjunction with Lewis. . . . product line sold to Solaron Corp. (Colorado) in 1978; new line doubled size of company. . . . Solaron recently entered licensing agreement with Jacorossi-AGIP, an Italian manufacturer, to sell collectors, under Solaron name, in 11 Western European nations; Olympic/National will also coat panels for Jacorossi. . . . Solaron's annual sales currently \$2 million; will receive 4% of Jacorossi's gross sales. (Conference/contact/Lewis, Purchased product line, TEF 600, Case Nos. 114859, A010333, 8/79)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- 50 Precision grinding tool: developed by Marshall to fabricate precision components for Saturn V guidance and control system. . . . new method for impregnating aluminum plates with diamond powder and hard-anodizing them to form grinding and polishing laps. . . . invention patented by NASA employee who formed Abernathy Laps Co. (Alabama) in 1966 to commercialize the laps. . . . company fills custom orders for laps in various sizes and shapes as well as diamond powder sizes. . . . unit prices range from \$170 to over \$1,100, and annual sales have been between \$20,000 and \$25,000. . . . sales expected to continue. . . . applications include fabrication of precision components and preparation of metallurgical specimens for analysis. (Former NASA employee, TEF 11, Case No. 119301, 5/79)
- 51 High-temperature strain measurement system: developed for Dryden by Boeing Aerospace Co., division of Boeing Co. . . . capacitive strain gage and signal conditioning system to measure stress-induced strain without thermal expansion strain. . . . Boeing obtained a patent waiver from NASA and issued an exclusive license to Hitec Corp. (Massachusetts) to commercialize the system. . . . company used thermal expansion strain cancellation design feature in developing new product, strain measurement gage with optional instrumentation package. . . . cost of gage alone is \$900; cost of complete system is \$1,200. . . . 1978 sales totaled \$200,000. . . . used in electric power plants and oil refineries to monitor stress in boilers, pipes and valves. (License/contractor, TEF 637, Case No. 119304, 7/79)
- 52 Differential temperature transducer: developed by Ames for an energy research project. . . . measured difference between inlet and outlet temperature for cooling water in an electric-arc heater. . . . patented by NASA Ames inventor obtained nonexclusive license and formed Delta-T Co. (California) in 1964 to commercialize the invention. . . . transducer produced in different sizes and sold for approximately \$470, depending on pipe size. . . . new version, called "Split Delta-T," recently introduced; two-part instrument provides greater flexibility. . . . price of new unit depends on configuration, most sell for about \$500. . . . annual sales of \$40,000 in early 1970's, increased to \$100,000 in 1978. . . . transducers provides accurate, rapid measurement of temperature difference, a critical parameter for analyzing heat flux in energy conversion equipment. . . . primary applications are fusion and solar energy research projects in government, university and private laboratories. (Personnel/Ames/license, TEF 222, Case No. 119300, 6/79)
- 53 Welding high-strength aluminum alloys: handbook compiled for Marshall integrates results from 19 research programs, including work done for Saturn V. . . . describes welding fabrication, aluminum alloy characteristics, weld defects and porosity, role of contaminants, weld thermal effects and residual stresses. . . . used by Reynolds Metals Co., Metallurgical Research Div. (Virginia) to improve welding techniques in its research activities. . . . specifically, the dry machining method of preparing surfaces for welding has become the standard technique recommended to customers who do precision welding. (TB/TSP, TEF 626, Case No. 105576, 10/78)

APPENDIX III

- 010 Aeronautics
 - 011 Aerodynamics
 - 012 Air Facilities (Ground)
 - 013 Aircraft
 - 014 Aircraft Flight Control and Instrumentation
 - SEE SEPARATE HEADING
Navigation, Air Traffic Control
- 020 Agriculture
 - 021 Agricultural Chemistry
 - 022 Agricultural Economics
 - 023 Agricultural Engineering
 - 024 Agronomy and Horticulture
 - 025 Animal Husbandry
 - 026 Forestry
- 030 Bearings
 - 031 Ball Bearings
 - 032 Bearing Tests
 - 034 Gas Bearings
 - 035 Journal Bearings
 - 036 Roller Bearings
 - 037 Seals
 - 038 Thrust Bearings
- 040 Biomaterials
 - 041 Prosthetic Devices (External)
 - 042 Prosthetic Devices (Internal)
- 050 Biomedical
 - 051 Cardiovascular and Hematology
 - 052 Clinical Chemistry and Microbiology
 - 053 Countermeasures
 - 054 Endocrinology, Metabolism and Nutrition
 - 055 Gastrointestinal
 - 056 Musculoskeletal
 - 057 Neurophysiology
 - 058 Reproductive
 - 059 Respiratory
- 070 Biosciences
 - 071 Developmental and Genetic Biology
 - 072 Human Behavior and Performance
 - 073 Radiobiology
 - 074 Regulatory Biology (Biorythms)
 - 075 Sensory Systems and Neurobehavioral Studies
- 080 Biotechnology
 - 081 Biodata Management and Modeling
 - 082 Bioinstrumentation
 - 083 Habitability
 - 084 Human Augmentation and Teleoperators
 - 085 Image Processing and Diagnostic Imaging
 - 086 Man-Machine
 - 087 Protective Clothing and Equipment
 - 088 Rehabilitation
 - 089 Remote Emergency Health Care Technology
- 090 Businesses
 - 091 Banking and Investment
 - 092 Insurance
 - 093 Retail Trade
- 100 Chemistry
 - 101 Chemical Analysis
 - 102 Chemical Elements and Compounds
 - 103 Chemical Processes and Engineering
 - 104 Radiochemistry
 - 105 Theoretical Chemistry
 - SEE SEPARATE HEADINGS
Agriculture, Agricultural Chemistry, Biomedical, Clinical Chemistry and Microbiology
- 110 Communications
 - 111 Communications Equipment
 - 112 Communications Systems and Techniques
 - 113 Communications Theory
 - 114 Radio and Radar
 - 115 Telecommunications
 - 116 Telemetry
 - 117 Tracking Systems
 - 118 Wave Propagation

*From the Miracode Application/Technical Subject Areas Index. For clarification of terms see Indexes I and II.

- 130 Computers
 - 131 Computer Hardware
 - 132 Computer Input/Output Devices
 - 133 Computer Process Control
 - 134 Computer Software
 - 135 Computer Systems
 - SEE SEPARATE HEADINGS
 - Biotechnology, Image Processing and Diagnostic Imaging
 - Information Management Technology
- 140 Construction
 - 141 Architecture
 - 142 Buildings
 - 143 Construction Equipment
 - 144 Construction Materials and Supplies
 - 145 Construction Safety
 - 146 Construction Techniques
 - 147 Structures
- 150 Contamination Control
 - 151 Contamination Control Abatement
 - 152 Contamination Control Detection and Monitoring
 - 153 Contamination Control Prevention
- 160 Control Technology
 - 161 Control Systems
 - 162 Control Theory
 - 163 Controllers
- 170 Criminalistics/Law Enforcement Technology
- 180 Cryogenics
 - 181 Cryogenic Devices and Equipment
 - 182 Cryogenic Materials Properties
 - 183 Cryogenic Principles
 - 184 Cryogenic Storage and Transfer
 - 185 Cryogenic Techniques and Processes
- 190 Education
 - 191 Conferences, Symposia, Colloquia
 - 192 Educational Evaluation Techniques
 - 193 Educational Facilities
 - 194 Educational Programs
 - 195 Teaching Aids/Materials
 - 196 Training Procedures
- 200 Electrical Generating Equipment
 - 201 Electric Generators
 - 202 Fuel Cells
 - 203 Magnetohydrodynamics (MHD)
 - 204 Nuclear Reactors
 - 205 Solar Cells
 - 206 Thermionic/Thermoelectric Generators
 - 207 Turbomachinery
 - 208 Wind Generators
- 210 Electrical Systems
 - 211 Circuits
 - 212 Electrodes
 - 213 Electromagnets
 - 214 Motors
 - 215 Transformers
 - 216 Transmission Systems
 - 217 Electrical Appliances
- 220 Electro-Magnetic Radiation
 - 221 Infrared
 - 222 Lasers and Masers
 - 223 Microwave
 - 224 Radio Frequency
 - 225 Ultraviolet
 - 226 X-Ray
- 230 Electronic Equipment
 - 231 Antennas
 - 232 Electronic Components
 - 233 Electronic Equipment Testing
 - 234 Semiconductor Devices and Transistors
- 240 Energy Systems
 - 241 Combustion
 - 242 Industrial Heating Equipment
 - 243 Solar Heating and Cooling
 - 244 Space Heating and Air Conditioning
 - 245 Storage
 - SEE SEPARATE HEADINGS
 - Electrical Generating Equipment
 - Propulsion Systems
- 250 Environment
 - 251 Conservation
 - 252 Land Use
 - 253 Meteorology
 - 254 Natural Resources
 - 255 Waste Management
 - 256 Wildlife
 - SEE SEPARATE HEADING
 - Pollution

- 260 Fabrication Technology
 - 261 Assembling
 - 262 Forming Techniques
 - 263 Joining
 - 264 Plating and Coating
 - 265 Tubing and Ducts
 - 266 Surface Treatments
 - SEE SEPARATE HEADINGS
 - Construction
 - Welding Technology
- 270 Fatigue Analysis
 - 271 Fatigue Analysis Analytic Methods
 - 272 Fatigue Analysis Test Equipment and Procedures
 - 273 Materials Properties
 - 274 Thermal Fatigue
- 280 Fibers and Textiles
 - 281 Materials
 - 282 Textile Equipment
 - 283 Textile Manufacturing Processes
 - SEE SEPARATE HEADING
 - Fire Safety, Nonflammable Materials
- 290 Fire Safety
 - 291 Fire Prevention and Detection
 - 292 Firefighting Equipment
 - 293 Flammability Testing
 - 294 Nonflammable Materials
- 300 Fluid Mechanics
 - 301 Fluidics
 - 302 Gas Dynamics
 - 303 Hydrodynamics and Hydrofoils
- 310 Food Technology
 - 311 Food Packaging
 - 312 Food Preservation
 - 313 Food Processing
 - 314 Food Production
 - 315 Nutrition
- 320 Fracture Mechanics
 - 321 Fracture Mechanics Materials
 - Composition
 - 322 Fracture Mechanics Test Equipment and Procedures
 - 323 Fracture Theory
 - 324 Materials Properties
- 330 Fuels
 - 331 Chemical Fuels (other)
 - 332 Coal
 - 333 Geothermal
 - 334 Hydrogen
 - 335 Natural Gas
 - 336 Nuclear
 - 337 Oil
- 340 Geophysics
 - 341 Atmospheric Physics
 - 342 Cartography
 - 343 Geodesy
 - 344 Geography
 - 345 Geology
 - 346 Gravitation
 - 347 Oceanography
 - 348 Terrestrial Magnetism
- 350 Home Economics
 - 351 Home Safety
 - 352 Household Equipment
- 360 Industrial Practice
 - 361 Corporate Marketing Programs
 - 362 Corporate Technology Transfer Programs
 - 363 Patent and Licensing Information
 - 364 Societies and Associations
- 370 Information Management Technology
 - 371 Display Media
 - 372 Information Dissemination Systems
 - 373 Recording Devices and Techniques
 - 374 Storage and Retrieval Systems
- 380 Legislation
- 390 Lubrication
 - 391 Friction and Wear
 - 392 Lubricant Testing
 - 393 Lubricants
 - 394 Lubrication Processes
 - 395 Lubrication Systems
- 400 Machinery and Tools
 - 401 Compressors
 - 402 Hand Tools
 - 403 Machine Tools
 - 404 Pumps
 - 405 Vacuum Equipment

- 410 Management and Administration
 - 411 Budgetary/Economic Information
 - 412 Management Planning
 - 413 Management Principles
 - 414 Management Systems
 - 415 Office Equipment
- 430 Manufacturing
 - 431 Automation
 - 432 Machining and Milling
 - 433 Manufacturing Processes
 - 434 Manufacturing Safety
 - 435 Manufacturing Specifications and Standards
 - 436 Product Design and Development
 - 437 Product Safety
 - 438 Production Management
 - SEE SEPARATE HEADINGS
 - Construction
 - Fabrication Technology
 - Industrial Practice
 - Machinery and Tools
 - Welding Technology
- 440 Materials (Nonmetallic)
 - 441 Adhesives and Sealants
 - 442 Ceramics
 - 443 Coatings and Films
 - 444 Composite Materials
 - 445 Elastomers
 - 446 Plastics
 - 447 Solvents, Cleaners and Abrasives
 - SEE SEPARATE HEADINGS
 - Fibers and Textiles
 - Lubrication, Lubricants
- 690 Mathematics
 - 691 Applied Mathematics
 - 692 Statistics
- 450 Metals and Alloys
 - 451 Corrosion and Erosion
 - 452 Ferrous Alloys
 - 453 Hardening Techniques
 - 454 Metallurgy and Metallography
 - 455 Nonferrous Alloys
 - 456 Pure Metals
- 460 Military Science
- 480 Navigation
 - 481 Air Traffic Control
 - 482 Navigation Instruments
 - 483 Navigational Guidance and Control
- 490 Nondestructive Testing
 - 491 Chemical and Spectrographic Analysis
 - 492 Eddy Current
 - 493 Liquid Penetrant
 - 494 Magnetic Particle
 - 495 Radiography
 - 496 Ultrasonics
- 500 Occupation and Work
 - 501 Occupational Certification Tests and Procedures
 - 502 Occupational Mobility
 - 503 Occupational Safety
 - 504 Unions
- 510 Optics
 - 511 Optical Communication
 - 512 Optical Equipment
 - 513 Optical Methods and Procedures
 - 514 Optical Properties
 - SEE SEPARATE HEADINGS
 - Communications, Telecommunications
 - Photography
- 520 Photography
 - 521 Photoanalysis
 - 522 Photographic Equipment
 - 523 Photographic Techniques

- 530 Physics
 - 531 Acoustics
 - 532 Electricity and Magnetism
 - 533 Nuclear and Atomic Physics
 - 534 Plasma Physics
 - 535 Scientific Instruments
 - 536 Solid-State Physics
 - 537 Thermodynamics
 - SEE SEPARATE HEADINGS
 - Communications, Wave Propagation
 - Cryogenics
 - Electro-Magnetic Radiation
 - Fluid Mechanics
 - Geophysics
 - Optics
 - Space Sciences
- 540 Pollution
 - 541 Air Pollution
 - 542 Noise Pollution
 - 543 Thermal Pollution
 - 544 Water Pollution
- 550 Propulsion Systems
 - 551 External Combustion Engines
 - 552 Gas Turbine Engines
 - 553 Internal Combustion Engines
 - 554 Rocket Engines
- 560 Public Sector Activities and Programs
 - 561 Federal Government
 - 562 International Government
 - 563 Local Government
 - 564 State Government
- 570 Recreation and Leisure
- 590 Reliability and Quality Assurance
 - 591 Failure Modes and Effects Analysis
 - 592 Quality Control
 - 593 Quality Management and Standards
 - SEE SEPARATE HEADING
 - Nondestructive Testing
- 600 Remote Sensing
 - 601 Remote Sensing Data Analysis
 - 602 Remote Sensing Equipment
 - 603 Remote Sensing Techniques
 - SEE SEPARATE HEADING
 - Photography
- 610 Safety
 - 611 Automotive Safety
 - 612 Aviation Safety
 - 613 Marine Safety
 - 614 Mine Safety
 - 615 Rail Safety
 - SEE SEPARATE HEADINGS
 - Construction, Safety
 - Fire Safety
 - Home Economics, Safety
 - Manufacturing, Safety
 - Occupation and Work, Safety
 - Product Safety
 - Urban Concerns, Safety
- 620 Satellites (Unmanned)
 - 621 Communications Satellites
 - 622 Earth Resources Technology
 - Satellites (ERTS and LANDSAT)
 - 623 Educational Satellites
 - 624 Geodetic/Geophysical Satellites
 - 625 Meteorological Satellites
 - 626 Navigation Satellites
 - 627 Orbiting Observatories
 - 628 Space Probes
- 630 Space Sciences
 - 631 Astronomy
 - 632 Astrophysics
 - 633 Cosmology
 - 634 Lunar Exploration
 - 635 Meteors and Meteorites
 - 636 Orbit and Trajectory Analysis
 - 637 Planetary Exploration
 - 638 Planets

- 640 Structural Mechanics
 - 641 Materials Properties
 - 642 Reinforced Structures
 - 643 Structural Analysis
 - 644 Structural Mechanics Impact
 - Phenomena
 - 645 Structural Members
 - SEE SEPARATE HEADINGS
 - Fatigue Analysis
 - Fracture Mechanics
- 660 Transportation
 - 661 Automotive Transportation
 - 662 Marine Transportation
 - 663 Mass/Rail Transit Systems
 - 664 Rail Transportation
 - SEE SEPARATE HEADING
 - Aeronautics
- 670 Urban Concerns
 - 671 Public Programs
 - 672 Urban Planning
 - 673 Urban Problems
 - 674 Urban Safety
 - 675 Urban Systems
 - SEE SEPARATE HEADING
 - Environment
- 680 Welding Technology
 - 681 Weld Test and Inspection Equipment
 - 682 Welding Accessories
 - 683 Welding Equipment Design
 - 684 Welding Processes
 - 685 Welding Techniques and Procedures

APPENDIX IV

Note: Whenever the code for "other" is chosen, write down on the coding sheet what it stands for.

1. File number
coding: 1000-9999
spaces: 4
2. Case number
coding: 01-99
spaces: 2
3. Year of most recent contact
coding: last two digits of year, e.g., 1982=82
spaces: 2
4. Year of case origin (i.e., year we first made contact)
coding: last two digits of year, e.g., 1982=82
spaces: 2
- *5,6,7,8,9. Technical subject area(s)
coding: see separate sheets
spaces: 5 choices @ 3 digits
- *10,11,12. NASA installation(s) of technology or contract origin
coding: ARC=Ames Research Center
FRC=Hugh L. Dryden Flight Research Center
GSFC=Goddard Space Flight Center
JSC=Lyndon B. Johnson Space Center/Manned Spacecraft Center (MSC)
KSC=John F. Kennedy Space Center
LARC=Langley Research Center
LERC=Lewis Research Center
MSFC=George C. Marshall Space Flight Center (also Michoud)
JPL=Jet Propulsion Laboratory/NASA Resident (Pasadena) Office (NPO)
WFC=Wallops Flight Center
HQN=NASA Headquarters
WOO=Western Operations Office
NSTL=National Space Technology Laboratories
ERC=Electronics Research Center
SNSO=Space Nuclear Systems Office
SNPO=Space Nuclear Propulsion Office
spaces: 3 choices @ 7 letters
- 13,14,15,16,17. Modes of dissemination, transfer mechanism(s)
coding: 01=Tech Briefs
02=other NASA publication(s)
03=NASA Field Center/Headquarters/Facility (not part of TUP network)
04=TUO
05=IAC/STAC/COSMIC
06=BAT/TAT/MAT
07=NASA conference, symposium, etc.
08=NASA innovator/inventor
09=former NASA employee (personnel transfer)
10=NASA partnership agreement, e.g., JEA, TEA, IGI
11=contractor/subcontractor
12=former contractor employee (personnel transfer)
13=trade press, professional journal, other media sources
14=non-NASA conference, meeting, etc., including subsequent papers and proceedings
15=non-NASA personal contact, e.g., colleague or customer
77=other 88=NA 99=unknown
spaces: 5 choices @ 2 digits

CASECODE (continued)

- *18,19,20,21,22. Use (application) subject area(s)
coding: see separate sheets
spaces: 5 choices @ 3 digits
23. Stage of technology when transferred
coding: 1=basic research
2=applied research
3=development
4=post-development
7=other
9=unknown
spaces: 1
24. Stage of application (if more than one applies, take the highest)
coding: 1=no use
2=acquiring information
3=learning more about a technical area
4=evaluating for potential use in a process/product/service
5=performing R&D or prototype testing
6=changing an existing process/product/service
7=developing a new process/product/service
8=other
9=unknown
spaces: 1
- 25,26,27. User transfer mechanism(s), i.e., how user received information about the technology and its existence
coding: same as for numbers 13-17
spaces: 3 choices @ 2 digits
28. Transfer status
coding: 1=complete (inactive)
2=terminated (inactive)
3=continuing (active)
7=other
9=unknown
spaces: 1
- 29,30,31,32,33,34,35. Estimated value, descriptive
a. product/process/service improved
b. net time/materials savings
c. sales/income increased
d. productivity increased
e. working conditions improved
f. living conditions (quality of life) improved
g. other
coding: Y(es)
spaces: 7
36. Estimated value, monetary
coding: dollars in thousands, e.g., \$2,597,500=2598
888888=NA:
999999=unknown
spaces: 6
37. Proprietary data flag
coding: Y/N
spaces: 1

CASECODE (continued)

- *38. Parent institution/organization name
coding: alpha (see abbreviations sheet)
spaces: 50
39. Relationship of user entity to parent institution
coding: 1=same
2=local plant
3=division
4=subsidiary
5=affiliate
7=other (e.g., department or laboratory)
9=unknown
spaces: 1
- *40. Location of user entity (number 39)
coding: AL=Alabama NV=Nevada
AK=Alaska NH=New Hampshire
AZ=Arizona NJ=New Jersey
AR=Arkansas NM=New Mexico
CA=California NY=New York
CO=Colorado NC=North Carolina
CT=Connecticut ND=North Dakota
DE=Delaware OH=Ohio
FL=Florida OK=Oklahoma
GA=Georgia OR=Oregon
HI=Hawaii PA=Pennsylvania
ID=Idaho RI=Rhode Island
IL=Illinois SC=South Carolina
IN=Indiana SD=South Dakota
IA=Iowa TN=Tennessee
KS=Kansas TX=Texas
KY=Kentucky UT=Utah
LA=Louisiana VT=Vermont
ME=Maine VA=Virginia
MD=Maryland WA=Washington
MA=Massachusetts WV=West Virginia
MI=Michigan WI=Wisconsin
MN=Minnesota WY=Wyoming
MS=Mississippi DC=Washington, DC
MO=Missouri XX=international (non-U.S.)
MT=Montana ZZ=unknown
NE=Nebraska
spaces: 2
41. Size of user entity (number 39), i.e., number of employees
coding: raw number
88888=NA
99999=unknown
spaces: 5
42. Annual sales of user entity (number 39)
coding: dollars in thousands, e.g., 4,500,000,000=4500000
88888888=NA
99999999=unknown
spaces: 8
43. Product of user entity (number 39)
coding: see separate sheet
spaces: 3

CASECODE (continued)

44. Source of case lead, i.e., how we learned of the case

coding: 01=TSP requester

02=media

03=NASA TUP (including SRI, Spinoff)

04=patent counsel

05=NASA PR

06=other NASA

07=contractor

08=conference, etc. attendee

09=another case contact or same contact on another case

77=other

99=unknown

spaces: 2

45. Case potential

coding: 01=Spinoff candidate only

02=notebook candidate only

03=Spinoff and notebook

04=notebook and followup

05=Spinoff, notebook, and followup

06=notebook and extended case study

07=Spinoff, notebook, and extended case study

08=extended case study

09=for update only, e.g., too much proprietary information
or too early in the transfer process

10=no followup

77=other

spaces: 2

46. Date of recontact

coding: month/year, e.g., January 1983=0183

8888=NA, inactive case, no recontact

9999=unknown, no date suggested

spaces: 4

*notebook index variables